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ELECTRICAL CABLE AND METHOD OF MAKING

BACKGROUND

[0001] The present invention relates generally to the field of electrical cables and more specifically to the field of making litz wire.

[0002] In a wide variety of applications, litz wire (also called "litzendraht wire") is used to reduce the high frequency impedance of electrical cables. A typical litz wire consists of a number of individually insulated conductors woven together so that each conductor assumes all possible positions in the cross section of the assembly. This arrangement of the conductors tends to reduce high frequency eddy current effects, thereby resulting in lower high frequency impedance.

[0003] The woven litz wire, while providing high performance, is sometimes prohibitively expensive for some applications owing to difficulty in its manufacture. Opportunities exist, therefore, to reduce the cost of litz wire and expand the number of applications by finding an alternative, less costly method of manufacture.

SUMMARY

[0004] The opportunities described above are addressed, in one embodiment of the present invention, by a method of making an electrical cable, the method comprising: bonding a plurality of electrical conductors to respective neighboring ones of the electrical conductors to form a ribbon, the electrical conductors being electrically insulated from the respective neighboring ones; folding the ribbon to form a cable assembly, each of the electrical conductors traversing the width of the cable assembly at least twice; optionally bonding the cable assembly; and optionally coiling the cable assembly.

DRAWINGS

[0005] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0006] Figure 1 illustrates an orthographic view of a ribbon in accordance with one embodiment of the present invention.

[0007] Figure 2 illustrates an orthographic view of an electrical cable in accordance with the embodiment of Figure 1.

[0008] Figure 3 illustrates an orthographic view of a ribbon in accordance with another embodiment of the present invention.

[0009] Figure 4 illustrates an orthographic view of a ribbon in accordance with another embodiment of the present invention.

[0010] Figure 5 illustrates an orthographic view of an electrical cable in accordance with another embodiment of the present invention.

[0011] Figure 6 illustrates an orthographic view of a ribbon in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

[0012] In accordance with one embodiment of the present invention, Figure 1 illustrates an orthographic view of a ribbon 120. A method of making an electrical cable starts by bonding a plurality of electrical conductors 110 to respective neighboring ones of electrical conductors 110 to form ribbon 120, where electrical conductors 110 are electrically insulated from their respective neighbors. Ribbon 120 is then folded as shown in Figure 2 to form cable assembly 130. The folding is performed so that each of electrical conductors 110 traverses the width of cable assembly 130 at least twice. In some embodiments, electrical cable 100 is then

completed by bonding cable assembly 130 to hold the folded shape. In some embodiments, such as, for example, in magnetic component applications, electrical cable 100 is completed by coiling cable assembly 130. In some embodiments, coiling cable assembly 130 is facilitated by bending cable assembly 130 to form corners during the act of folding.

[0013] In another embodiment of the present invention, cable assembly 130 is folded such that electrical conductors 110 do not describe spirals around cable assembly 130.

[0014] In another embodiment of the present invention, cable assembly 130 is folded lengthwise before bonding to produce a thicker cable.

[0015] In another embodiment of the present invention, Figure 3 illustrates a bonding layer 170 applied to ribbon 120 prior to folding. In some embodiments, bonding layer 170 is electrically insulating. Examples of bonding layer 170 include, without limitation, adhesives and curable polymers.

[0016] In another embodiment of the present invention, bonding layer 170 is cured by exposure to a bonding stimulus. Examples of bonding stimuli include, without limitation, electromagnetic radiation, mechanical stimuli, and chemical stimuli.

[0017] Figure 4 illustrates ribbon 120 in accordance with another embodiment of the present invention. In the embodiment of Figure 4, bonding each of electrical conductors 110 to a respective neighbor is accomplished by bonding the plurality of electrical conductors 110 to a common cable substrate 140. In some embodiments, cable substrate 140 is electrically insulating. In some embodiments, electrical conductors 110 are spaced apart from their respective neighbors.

[0018] In another embodiment, each of electrical conductors 110 has a non-rectangular cross section. By way of example, but not limitation, circular cross sections may be used. In some embodiments, ribbon 120 is further processed by being rolled flat prior to being folded.

[0019] In another embodiment, illustrated in Figure 4, the capacitance of electrical cable 100 is influenced by selectively coupling electrical conductors 110. At a first end of cable assembly 130, a subset of electrical conductors 110 is electrically coupled to produce a first coupled subset 150, leaving an uncoupled remainder of electrical conductors 110. The uncoupled remainder of electrical conductors 110 are then electrically coupled at a second end of cable assembly 130 to produce a second coupled subset 160. In some embodiments, the first end and second end are at the same end of cable assembly 130. In other embodiments, the first end and second end are at opposite ends of cable assembly 130.

[0020] In another embodiment in accordance with the embodiment of Figure 4, members of first coupled subset 150 have different respective lengths. Members of second coupled subset 160 have lengths in one-to-one correspondence with the different respective lengths of the members of first coupled subset 150. By varying the lengths of electrical conductors 110 in this embodiment, the capacitance is influenced as a function of length along electrical cable 100, thus influencing the lengthwise current distribution.

[0021] In another embodiment in accordance with the embodiment of Figure 4, a first insulating gap is produced at a first gap location along the length of first coupled subset 150. In some embodiments, a second insulating gap is produced at a second gap location along the length of second coupled subset 160. The first and second insulating gaps also serve to alter overall cable capacitance.

[0022] In another embodiment in accordance with Figure 4, electrical conductors 110 are bonded to opposite faces of cable substrate 140. In another embodiment, after folding, electrical conductors 110 are disposed on an outer surface of cable assembly 130.

[0023] Figure 5 illustrates another embodiment wherein ribbon 120 is folded around an insulating strip 180.

[0024] Figure 6 illustrates another embodiment wherein electrical conductors 110 are formed into diagonal patterns 190. In another embodiment, diagonal patterns 190

are formed on opposite faces of cable substrate 140 with opposite face pairs of electrical conductors 110 being coupled through coupling holes in cable substrate 140. In another embodiment, opposite face pairs of electrical conductors 110 are coupled at the edges of substrate 140.

[0025] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.